

Attorney's Docket No.: 06618/736001

REMARKS

Reconsideration and allowance of the above application are respectfully requested.

Claims 1-12 are allowed. Claims 13-20 and 24-32 are rejected. In response, Claims 12 and 24 have been amended to clarify their language. No new matter is added. Upon entry of the amendment, Claims 1-20 and 24-32 are pending and under consideration.

Claims 13, 14, 24, and 25 stand rejected under 35 USC 102(b) as being anticipated by Knight. Claim 13 as amended, Claim 14, Claims 24 and 25 are distinctly different from Knight and thus are patentable.

Claim 13 as amended recites "a first single-mode fiber for light at a first wavelength connected to a first side of said tapered fiber section, and a second single-mode fiber for light at a second wavelength connected to a second side of said tapered fiber section." Notably, Claim 13 as amended specifies that "said first and said second wavelengths are different." Hence, the recited first and second single-mode fibers are different single-mode fibers for two different wavelengths. This structural feature provides, among others, a unique optical coupling operation where light at the two different wavelengths can be evanescently coupled into and out of the recited tapered fiber section.

In contrast, Knight discloses a tapered section formed in the middle of a monomode fiber, i.e., a single-mode fiber (Abstract, column 2 on page 1129, and column 1 on page 1130). Two opposite sides of the tapered fiber section connect to identical untapered single-mode fiber sections that support a single mode of light at the same optical wavelength. Knight

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specifically teaches formation of the tapered section from the same single-mode fiber by heating and stretching a section of the same fiber (column 1 on page 1129). Hence, in Knight's coupler, the untapered fiber section at one end of the tapered section is identical to the other untapered fiber section on the opposite side of the taper fiber section.

Therefore, Claim 13 as amended is patentable under 35 USC 102(b) over Knight. Claim 14 is dependent on Claim 13 and thus is patentable based on at least the above reasons set forth for Claim 13.

Similarly, Claim 24 as amended and its dependent Claim 25 are patentable over Knight based on the above reasons for Claim 13.

Based on the above, it is respectfully suggested that the rejections under 35 USC 102(b) based on Knight lack the required support in Knight and thus must be withdrawn.

Claims 13-19 stand rejected under 35 USC 103(b) over Cai in view of Knight. Applicants respectfully traverse the rejections.

Claim 13 as amended recites "a first single-mode fiber for light at a first wavelength connected to a first side of said tapered fiber section, and a second single-mode fiber for light at a second wavelength connected to a second side of said tapered fiber section." Notably, Claim 13 as amended further recites that "said first and said second wavelengths are different." Hence, the first single-mode fiber for light at the first wavelength is different from the second single-mode fiber for light at the second wavelength.

The cited Cai reference is Applicants' own publication. In that publication, the fiber sections connected to the fiber taper were made from the same fiber and thus were identical to each other. Therefore, the fiber sections in Cai's fiber taper

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cannot be "a first single-mode fiber for light at a first wavelength" and "a second single-mode fiber for light at a second wavelength" that is different from the first wavelength because they are identical and can only be a single-mode fiber at one of the two wavelengths at 976 nm and 1500 nm described in Cai. As discussed above, in Knight's coupler, the untapered fiber section at one end of the tapered section is identical to the other untapered fiber section on the opposite side of the taper fiber section and thus suffer the same limitation as Cai for the two wavelengths at 980 nm and 1500 nm.

As a result, the combination of the Cai and Knight fails to teach or suggest "a first single-mode fiber for light at a first wavelength connected to a first side of said tapered fiber section, and a second single-mode fiber for light at a second wavelength connected to a second side of said tapered fiber section" as recited in Claim 13 as amended. As such, Claim 13 as amended is distinctly different from the combination of Cai and Knight and thus are patentable under 35 USC 103(a).

In the cited Cai reference, the fiber taper is described to guide both a pump laser at 976 nm and the laser light at 1500 nm in addition to optical coupling at the tapered region. Knight's coupler is described to operate at the similar two wavelengths. Such fiber tapers can operate but suffer in coupling efficiency.

It is known in the field of fiber optics that a single-mode fiber at a specified wavelength supports the fundamental mode for light at the specified wavelength, but not higher order modes at the same specified wavelength. Assuming that a tapered fiber coupler uses 1550-nm single-mode fiber based on Cai and Knight, let us examine how this coupler operates when a pump light at a shorter wavelength, e.g., around 980 nm, is received at one end of the coupler. The receiving end is formed from the same 1550-nm single mode fiber like the corresponding part on

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the opposite side of the coupler. Because the diameter of the 1550-nm single mode fiber is larger than that of a 980-nm single mode fiber, the receiving end of the coupler can support both the fundamental mode of the 980-nm light and higher order modes of the 980-nm light. Thus, it is not a single-mode fiber for light at 980 nm. The presence of higher order modes of the 980-nm light in the receiving end reduces the input optical power of the 980-nm light in the fundamental mode at 980 nm because part of input optical energy at 980 nm is in the higher order modes at 980 nm. In other words, only partial input power at 980 nm is transferred to the 980-nm fundamental mode at the receiving end and in the tapered region. Pump power carried by the higher order modes is lost or converted into higher order modes at 980 nm at the tapered region.

Therefore, when the coupler is used to couple the 980-nm fundamental mode into a WGM cavity and to couple 1550-nm light out of the WGM cavity, the coupling for the 980-nm fundamental mode is less efficient as the 1550-nm fundamental mode. This compromises the optical pumping efficiency of the system.

On the other hand, if the coupler based on Cai and Knight is formed from a 980-nm single-mode fiber, the above optical loss at the 980-nm fundamental mode is avoided. However, due to the small diameter of the 980-nm single-mode fiber, the insertion loss for the 1550-nm light will be large. Therefore, the coupling and transmission at 1550 nm are compromised.

Clearly, the use of the same single-mode fiber in two ends of the fiber taper coupler significantly limits its operations and performance in applications where two optical wavelengths are involved such as optical amplifiers and optically-pumped lasers based on WGM resonators.

Applicants recognized the limitations in their own prior work as described in the cited Cai reference. Based on such

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recognition, they invented a "hybrid" structure to mitigate the limitations in the cited Cai and Knight by connecting first and second single-mode fibers for different wavelengths to interface with a tapered fiber section. Hence, Claim 13 as amended represents a technical advance from the devices in the recited Cai and Knight in terms of optical coupling efficiency. As well known in fiber optics, optical loss at a coupling interface is one of the critical issues, e.g. in lasers and amplifiers.

In contrast, nothing in the cited Cai reference and Knight suggests a recognition of the optical loss issue in using the same fiber on both sides of the fiber taper. Lacking such recognition, it should not be surprising that the cited Cai reference and Knight, either individually or collectively, fail to provide any suggestion or teaching of the "hybrid" structure recited in Claim 13 as amended.

Therefore, Claim 13 as amended is not obvious over Cai and Knight and thus is patentable under 35 USC 103(a). For at least the above reasons, Claims 14-19 are patentable over Cai and Knight due to their dependence on Claim 13.

Claim 20 stands rejected under 35 USC 103(a) over Cai in view of Knight and in further view of Stone. Claim 20 is dependent on Claim 13. Hence, all arguments made in Claim 13 are applicable here. As discussed above, the combination of Cai and Knight fails to suggest or teach Claim 13 as amended. Stone certainly does not fill the void in Cai and Knight. Therefore, Claim 20 is patentable.

Claim 26 stands rejected under 35 USC 103(a) over Knight over Ho. Claim 26 is dependent on Claim 24. As discussed above for Claim 24, Knight fails to disclose the "hybrid" structure in Claim 24 as amended. Ho does disclose the "hybrid" structure either. Therefore, the combination of Knight and Ho fails to suggest or teach Claim 26. Claim 26 is patentable.

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Finally, Claims 27-32 stand rejected under 35 USC 103(a) over Knight in view of Cai. Claims 27-29 are dependent on the base Claim 24 as amended. Claim 24 as amended recites the "hybrid" structure as in Claim 13 as amended and thus is patentable over Knight and Cai. As a result, Claims 27-32 are patentable for at least this reason alone.

Turning to Claims 30-32, the device recited in the base Claim 30 includes a "hybrid" structure having a tapered waveguide section, a first waveguide supporting a single-mode at a first wavelength, and a second waveguide supporting a single-mode at a second wavelength that is longer than the first wavelength. As discussed above, both Cai and Knight fail to suggest this hybrid structure. Hence, Claims 30-32 are patentable over Knight and Cai.

In view of the above, Applicants respectfully submit that all pending claims are distinctly patentable over cited prior art. Each and every objection or rejection raised in the Office Action has been fully addressed and overcome. Accordingly, the application is now in full condition for allowance and an official notice of allowance is requested to be issued at an early date.

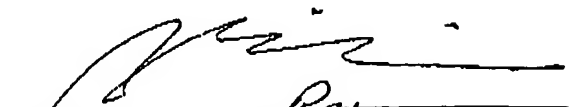
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Respectfully submitted,

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